

# COOLING HISTORY OF ALMAHATA SITTA UREILITE AS INFERRED FROM TRANSMISSION ELECTRON MICROSCOPY OF IRON METAL.

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**Introduction:** Almahata Sitta (AS) is a polymict breccia mainly composed of various ureilite lithologies with lesser chondritic lithologies [1]. In the ureilite lithologies, Fe metal is a common accessory phase present either as large grain boundary grains or small particles formed by reduction of olivine and pyroxene. In our earlier studies on grain boundary metals in one of AS fragments (#44) we found unique features never seen in other ureilites [2,3]. In order to further characterize these metal grains, we performed a detailed TEM study on a FIB section prepared from one of AS #44 grain boundary metals and here discuss its thermal history.

**Results:** The FIB section is composed of compositionally homogeneous Fe metal (93 Fe, 5 Ni, and 2 Si in wt%). However, BF-STEM images exhibited clear contrast composed of elongated laths (~2  $\mu\text{m}$  long) embedded in an interstitial matrix. The SAED patterns showed that these laths are  $\alpha$ -Fe (*bcc*) while interstitial areas are  $\gamma$ -Fe (*fcc*), suggesting the formation of two iron phases by the martensite transformation. High resolution TEM images of the  $\alpha$ -Fe laths further revealed a tweed-like texture, and the obtained SAED pattern shows the coexistence of both  $\alpha$ -Fe and  $\gamma$ -Fe with *K-S* crystallographic orientation relationship of martensite [e.g., 4].

**Discussion:** The formation of lath martensite from the Fe-Ni metal is clearly due to rapid cooling from high temperature where  $\gamma$ -Fe was stable. The presence of C and Si decreases the martensite transformation temperature in the Fe-Ni system [e.g., 5], and may have also enhanced its stability. We tried to estimate a cooling rate using this unique metal texture, but its complex composition with an unknown C amount does not allow us to simply employ a T-T-T diagram of the Fe-Ni-C system. The C abundance is known to significantly control the formation of martensite. However, since we did not see any Fe carbides and C could not be detected by EPMA, the C abundance must be low.

Fe metals in AS show textures and phase assemblages that are not seen in other ureilites. These features may be due to shock-reheating of various original grain boundary assemblages having different amounts of graphite, phosphide, silicide and troilite in an event that did not affect most main group ureilites but occurred on the AS/2008TC<sub>3</sub> body.

**References:** [1] Zolensky M. E. et al. 2010. *Meteoritics & Planetary Science* 45:1618-1637. [2] Goodrich C. A. et al. 2010. *Meteoritics & Planetary Science* 45:A66. [3] Mikouchi T. et al. 2011. *Meteoritics & Planetary Science* 46:5409. [4] Narasimha Rao B. V. 1979. *Metallurgical & Materials Transactions A* 10:645-648. [5] Sverdlin A. D. and Ness A. R. 1997. *Chapter 2, Steel Heat Treatment Handbook*, ed. by Tlitten G. E. & Howes M. A. H., Marcel Dekker Inc. NY.